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SOME EFFECTS OF SHADE COVER ON STREAM  
TEMPERATURE IN SOUTHEAST ALASKA

by

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## ABSTRACT

Water temperatures were recorded in several southeast Alaska streams with a portable thermometer accurate to  $0.01^{\circ}\text{C}$ . Measurements were made at 20-yard intervals in shaded and unshaded reaches and on cloudy and clear days. Results indicate that (1) the effects of streamside cover on stream temperatures can be evaluated by this technique, and (2) shade-producing streamside cover is important in maintaining cool water.

## INTRODUCTION

Clearcut logging of watersheds in southeast Alaska frequently includes removal of streamside timber. The effect of such removal on the suitability of southeast Alaskan streams as fish habitat is largely unknown, although studies in other parts of the United States have demonstrated that increased water temperatures often result. A similar determination under the climatic conditions of southeast Alaska would greatly facilitate decisions about the harvest of timber along salmon streams. Many of the small streams in southeast Alaska maintain substantial runs of salmon, especially pink salmon (*Oncorhynchus gorbuscha* (Walbaum)). In total, these small streams produce a significant percentage of the salmon pack for southeast Alaska. On the watersheds of many of these small streams much of Alaska's timber resources are found.

Eschner and Larmoyeux<sup>1/</sup> found that the average maximum stream temperature in a clearcut watershed in West Virginia was 8° F. higher than the control stream in an uncut watershed during the growing season and that, during the dormant season, the average minimum stream temperature was 3.5° F. lower in the clearcut watershed. Unpublished data from the USDA Forest Service, Pacific Southwest Forest and Range Experiment Station,<sup>2/</sup> show that stream temperatures in a cleared canyon in California were as much as 15° F. higher than those in a similar but uncleared canyon. Brown and Krygier<sup>3/</sup> indicated increases in stream temperature of up to 14° F. during warm summer periods in a clearcut watershed in Oregon. However, a recent paper<sup>4/</sup> reported a maximum increase in summer stream temperatures of only 9° F. after clearcutting in two watersheds near Hollis on Prince of Wales Island, Alaska. The cool, mostly overcast climate of southeast Alaska is probably the main reason for this relatively small change in stream temperature after logging. These studies reported the effects on stream temperature of clearcutting all or parts of the watershed.

Brown and Krygier also stated that streams with small flow volumes are affected sooner and to a greater extent by changes in air temperature and solar radiation than larger streams and rivers. Levno and Rothacher<sup>5/</sup> reported that exposing a large proportion of an Oregon streambed to solar radiation increased maximum stream temperatures and that excessive increases could be prevented by retaining streamside vegetation. Brown and Krygier (footnote 3) reported that removing streamside vegetation increased the mean monthly maximum temperature

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<sup>1/</sup> Eschner, Arthur R., and Larmoyeux, Jack. Logging and trout: Four experimental forest practices and their effect on water quality. Progr. Fish-Cult. 25: 59-67. 1963.

<sup>2/</sup> Semiannual report of USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, for April-September 1959.

<sup>3/</sup> Brown, George W., and Krygier, James T. Changing water temperatures in small mountain streams. J. Soil & Water Conserv. 22(6): 242-244. 1967.

<sup>4/</sup> Meehan, W. R., Farr, W. A., Bishop, D. M., and Patric, J. H. Some effects of clearcutting on salmon habitat of two southeast Alaska streams. Inst. Northern Forest., Pacific Northwest Forest & Range Exp. Sta. USDA Forest Serv. Res. Pap. PNW-82, 45 pp., illus. 1969.

<sup>5/</sup> Levno, Al, and Rothacher, Jack. Increases in maximum stream temperatures after logging in old-growth Douglas-fir watersheds. USDA Forest Serv. Pacific Northwest Forest & Range Exp. Sta. Res. Note PNW-65, 12 pp., illus. 1967.

14° F. on a clearcut watershed in Oregon's Alsea River basin. They also marked a mass of water with fluorescent dye (under clear skies near midday) and noted that its temperature increased 16° F. in 1 hour as it passed through a reach of stream where clearcutting had removed shade-producing vegetation and exposed the streambed to direct sunlight. The cooling effects of streamside vegetation on stream temperatures were observed by Green,<sup>6/</sup> who reported a decrease of 12° F. as a stream in North Carolina meandered 400 feet through forest and brush cover.

These scattered studies indicate that under various conditions, and in different areas of the United States, streamside vegetation is significant in determining the temperature regimen of a stream. In my study, I wished to determine the role of streamside vegetation under the cool, moist conditions of southeast Alaska. The study objectives were (1) to develop a practical method for measuring the effects of shade on stream temperature, and (2) to conduct exploratory studies of the relations between stream cover and water temperature.

## STUDY LOCATION AND METHODS

The studies were conducted in small streams in the northern part of southeast Alaska, near the towns of Wrangell, Petersburg, Juneau, and Haines (fig. 1, table 1). Some sections of the streams were in unshaded clearcut or naturally open areas, and other sections were shaded by streamside vegetation. Thus, the effects of solar radiation as well as cover could be observed in the same stream. Water temperatures were measured under two sky conditions: (1) clear, sunny days and (2) completely overcast days (table 1). Most measurements under both conditions were made near midday between 1000 and 1400 hours.

The basic technique was to measure precisely the differences in water temperature over short reaches of stream and to relate these differences to shade and cloud cover. Measurements were made at 20-yard intervals along the streams, in shaded and unshaded reaches, with a portable resistance thermometer which measured temperatures to the nearest 0.01° C. After the concluding measurement of a series of observations, the temperature at the starting point was remeasured to determine the change during the sampling time interval. This change factor was then used to adjust each reading so that the effect of such change was minimal. For better evaluation of results, the temperature ranges encountered on each stream have been noted in tables 2 and 3.

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<sup>6/</sup> Green, G. E. Land use and trout streams. J. Soil & Water Conserv. 5(3): 125-126. 1950.

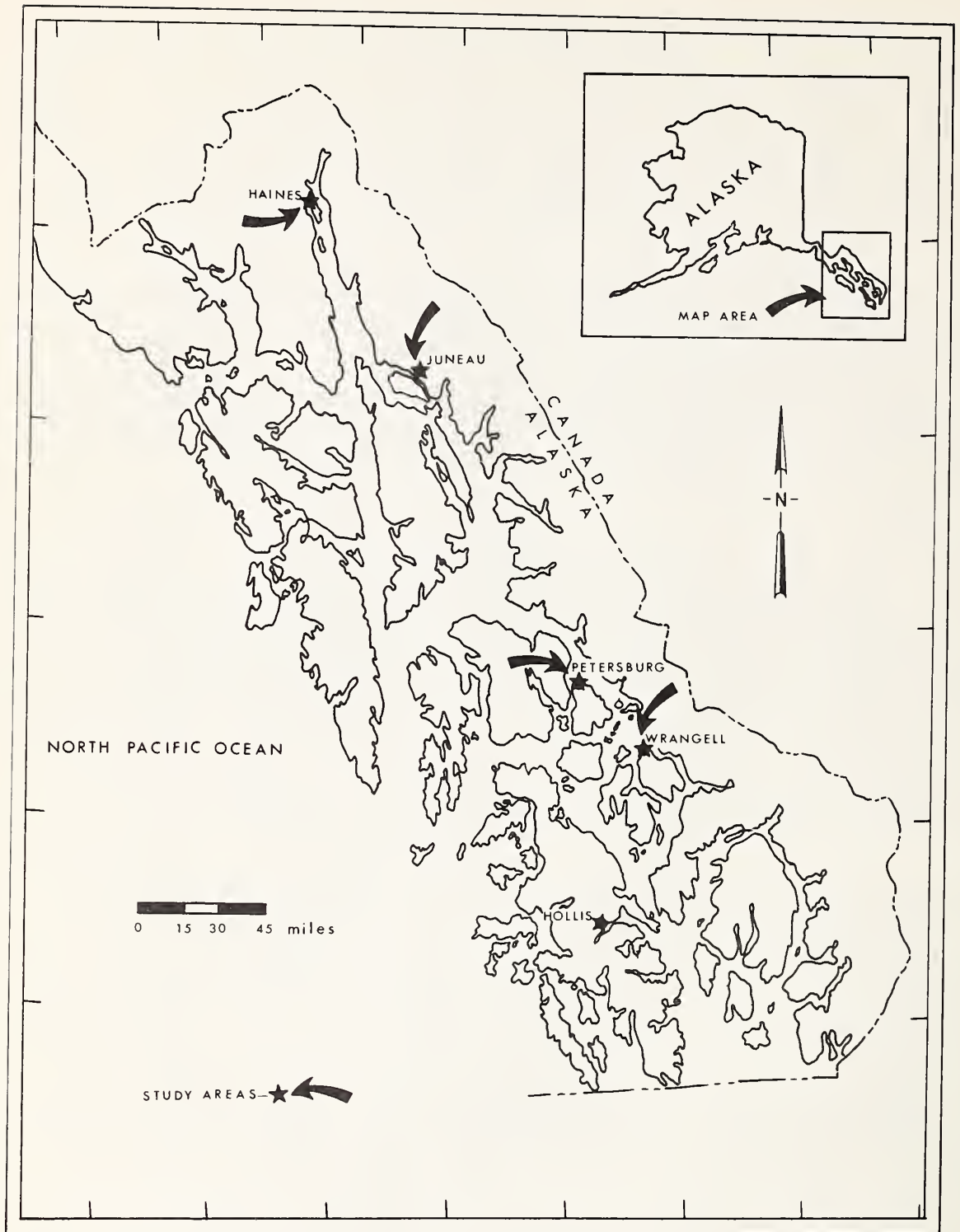


Figure 1.--*Southeast Alaska, showing location of study areas.*

Table 1.--Date and cloud cover at time temperatures were recorded  
in several streams in southeast Alaska, 1967

Area and stream <sup>1/</sup>	Date	Cloud cover
- - Percent - -		
Haines:		
"Temperature" Creek	Aug. 3	0
	Oct. 13	100
Big Boulder Creek	Aug. 3	0
	Oct. 13	100
"Clear" Creek No. 1	Aug. 3	0
"Clear" Creek No. 2	Aug. 3	0
Juneau:		
Sweitzer Creek	July 24	0
Montana Creek	July 25	0
Petersburg:		
Twin Creek	Aug. 16	0
	Oct. 22	100
Falls Creek	Aug. 17	0
	Oct. 22	100
Ohmer Creek	Aug. 16	0
	Oct. 22	100
Ohmer Creek tributary	Aug. 16	0
	Oct. 22	100
Blind River tributary	Aug. 16	0
	Oct. 22	100
"Foam" Creek	Aug. 17	0
	Oct. 22	100
Wrangell:		
Pat's Creek	Aug. 15	0

<sup>1/</sup> Creek names enclosed in quotation marks are unofficial names adopted for use in the study.

Table 2.--Average temperature difference per 20 yards of streams on clear days with and without shade-producing cover, in selected areas of southeast Alaska, 1967

Area and stream <sup>1/</sup>	Temperature range in stream length measured	Length of stream measured		Average temperature difference per 20 yards	
		Open	Shaded	Open	Shaded
	<i>Degree C.</i>	<i>-----Yards-----</i>		<i>-----Degree C.-----</i>	
Haines:					
"Temperature" Creek	10.37-11.77	620	60	+0.07	-0.05
Big Boulder Creek	12.59-12.85	360	80	+0.02	-.09
"Clear" Creek No. 1	<sup>2/</sup> 4.30- 5.39	280	340	<sup>2/</sup> +1.11	<sup>2/</sup> -.07
"Clear" Creek No. 2	<sup>2/</sup> 5.81- 6.33	380	400	<sup>2/</sup> +0.05	<sup>2/</sup> -.03
Juneau:					
Sweitzer Creek	8.23- 8.49	60	--	+0.09	--
Montana Creek	7.19- 8.67	240	60	+0.07	-.09
Petersburg:					
Twin Creek	10.40-11.09	100	40	+0.21	-.18
Falls Creek	13.70-13.94	40	60	+0.13	-.03
Ohmer Creek	13.06-13.40	80	120	+0.14	-.15
Ohmer Creek tributary	11.43-11.77	40	40	+0.21	-.18
Blind River tributary	11.70-12.13	100	140	+0.15	-.07
"Foam" Creek	12.00-13.61	120	60	+0.19	-.11
Wrangell:					
Pat's Creek	13.82-16.01	380	220	+0.14	-.08

<sup>1/</sup> Creek names enclosed in quotation marks are unofficial names adopted for use in the study

<sup>2/</sup> Observed value; temperature at first station not checked at end of series.

Table 3.--Average temperature difference per 20 yards of streams on overcast days,  
near Haines and Petersburg, Alaska, 1967

Area and stream <sup>1/</sup>	Temperature range in stream length measured	Length of stream measured	Average temperature difference per 20 yards
	<i>Degree C.</i>	<i>Yards</i>	<i>Degree C.</i>
Haines:			
"Temperature" Creek	4.71-5.11	300	+0.01
Big Boulder Creek	5.02-5.07	240	0
Petersburg:			
Twin Creek	5.57-5.59	120	0
Falls Creek	6.09-6.17	240	+0.01
Ohmer Creek	6.03-6.12	220	+0.01
Ohmer Creek tributary	5.61-5.65	140	+0.01
Blind River tributary	6.42-6.45	120	0
"Foam" Creek	6.25-6.32	140	+0.01

<sup>1/</sup> Creek names enclosed in quotation marks are unofficial names adopted for use in the study.

## RESULTS

The greatest range in temperature observed within any one stream was 2.30° C., within 600 yards in Pat's Creek in the Wrangell area. A temperature check at the starting point after all measurements were recorded showed that the stream had actually warmed 0.22° C. during the sampling interval, so that the extreme range of temperature increase was actually closer to 2.08° C; this temperature range was recorded on a clear, sunny day. The greatest range in temperature observed on an overcast day was 0.40° C. in "Temperature" Creek in the Haines area in 300 yards. This range is considerably higher than those of other streams in both areas measured under cloudy skies, because a slightly warmer tributary affected the main stream. The temperature range before this tributary was reached was 0.18° C. in 240 yards of measurements.

Temperature measurements at 20-yard intervals (tables 2 and 4) show that on clear summer days, shade-producing streamside vegetation plays a definite role in cooling or maintaining coolness of the study streams. The data also suggest that average temperature differences

Table 4.--Summary of mean temperature differences under various sky and cover conditions for streams in selected areas of southeast Alaska, 1967

Area and treatment	Number of temperature measurements taken	Average temperature difference
		<i>Degree C.</i>
Haines-Juneau:		
Clear-open	28	+0.071
Clear-shaded	12	-.060
Cloudy <u>1/</u>	27	+.011
Petersburg-Wrangell:		
Clear-open	38	+.164
Clear-shaded	31	-.081
Cloudy <u>2/</u>	49	+.009

1/ Haines only.

2/ Petersburg only.

per 20 yards in open reaches of stream on clear days were greater in Petersburg-Wrangell streams than in Haines-Juneau area streams. Analysis of variance showed the difference was significant ( $F = 16.52$ ). No significant difference was found between the two areas under clear-shaded and cloudy weather conditions.

## DISCUSSION

In southeast Alaska, water temperature in small streams is most affected by the presence or absence of shade-producing streamside vegetation on clear, sunny, midsummer days. Under these conditions solar radiation has its maximum effect.

This exploratory study shows that streamside vegetation is important in maintaining cool streams, particularly during the warm, clear weather that occurs at times between May and September in southeast Alaska. On overcast days, the effects are less pronounced. No explanation is suggested here for the significant difference between average stream temperature increases in the Haines-Juneau and Petersburg-Wrangell areas under clear, unshaded conditions. The range of temperatures measured was quite similar in streams of both areas. Relative humidity, soil temperature, and ground water addition all may have been influencing factors.

The results of the study conducted at Hollis (see footnote 4) should be considered in the light of the present findings. There, a maximum increase in stream temperature of 9° F. occurred during the summer months after the watersheds were clearcut. Hollis is typical of much of southeast Alaska in terms of weather, and field observations there from May through September for 3 years indicate that about 35 days of partly cloudy to clear skies can be expected during this 5-month period. It is quite likely that average stream temperatures in other areas with similar generally overcast weather conditions would be affected similarly by timber harvest. However, if the shade-producing canopy were allowed to remain, the daily variations in temperature would probably be smaller.

Probably the most important element in the effect of streamside vegetation on water temperature in southeast Alaska is the biological significance of increased temperatures. The results of this study and that near Hollis (see footnote 4) indicate that temperature increases after clearcutting in this region do not approach lethal limits for fish populations. However, the indirect effects of temperature increases on the environment, particularly in the case of resident fish populations, are not known. Some rise in temperature might increase the primary productivity of the stream, perhaps enhancing the feeding opportunities and growth of resident fish. Winter temperatures should likewise be considered; winter stream temperature differences resulting from streamside cover removal could have greater effects on fish populations in southeast Alaska than summer temperature increases. Warmer daytime water temperatures in winter could be beneficial; colder nighttime temperatures could be harmful. The total effect should be determined.

The results of this study indicate that further research is necessary. Measurements of solar radiation should be made concurrently with temperature. The roles of relative humidity, ground water addition to the stream, soil temperature, and thermal exchange by convection should be considered. In other words, the "micrometeorology" of the stream and its immediate surroundings should be more thoroughly investigated.

When the precise role of streamside vegetation in the aquatic environment is known, fisheries and land managers will be better able to prescribe clearcutting patterns that effect an optimum relationship between timber and salmon production.



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